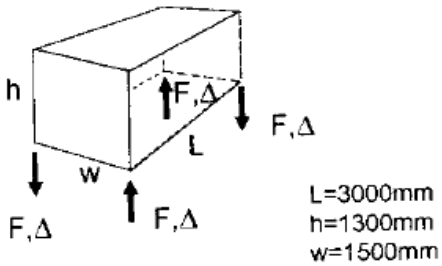
1. Consider the van box model for torsion. [35]

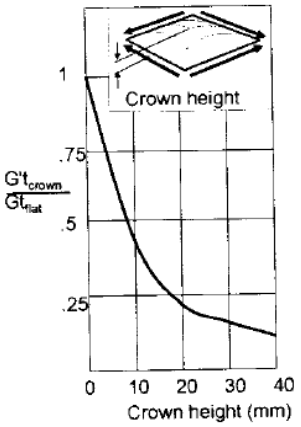
(1) Determine the shear loads in each panel when F = 8000N. (10 pts)

(2) Show that the torsional stiffness of box is $K = \frac{T}{\theta} = (2wh)^2 \frac{1}{\sum_{\text{all surfaces}} \left[\frac{ab}{(Gt)}\right]_i}$. (10 pts)

(3) Determine the torsional stiffness if all panels are perfectly flat panels 1mm thick. (G=80,000N/mm^2) (5 pts)

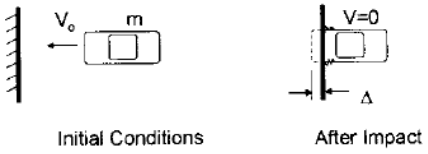
(4) If the van has a roof with 20mm of crown height, determine the torsional stiffness with a crown panel using the effective properties taken off the adjacent chart. (10 pts)





Van box model for torsion

2. A 1000kg car impacts a rigid barrier at V_0 = 48 km/h. It is desired that the maximum deceleration level be a_{max} = 20g. The anticipated crush efficiency is η = 0.8. Assume fully plastic behavior. [40]



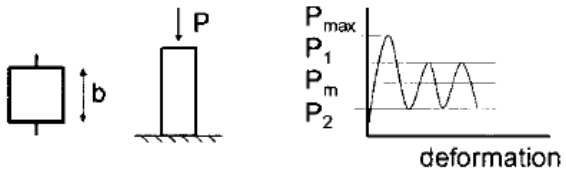
(1) What is the required crushable space Δ? (5 pts)

(2) What is the mean crush force which must be generated by the vehicle F_{avg}? (5 pts)

Assume that two midrails will provide 50% of the average crumpling force F_{avg} required. The body will be tested statically for this force level.

P_m : mean crush force (N)
P_{max} : maximum crush force (N)
t : material thickness (mm)
b : section width and height (mm)
σ_Y : material yield stress (N/mm^2)

$$\rightarrow \begin{cases} P_m = 386 t^{1.86} b^{0.14} \sigma_Y{}^{0.57} \\ P_{max} = 2.87 P_m \\ P_1 = 1.42 P_m \\ P_2 = 0.57 P_m \end{cases}$$



(3) Determine the maximum load for the square section P_{max}. (5 pts)

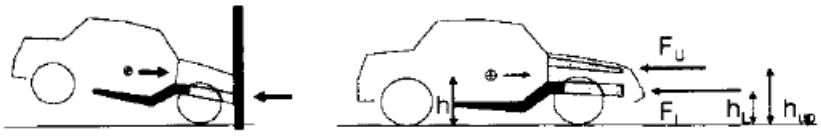
(4) What moment is needed at the toe pan to react the load in (3)? (5 pts)

(5) Determine the required section thickness at the toe pan so the load of part can be reacted if σ_{max} = 220 N/mm^2. The section is rectangular with height = 70 mm, width = 40 mm. (10 pts)

(6) Crush initiators are added to the front part of the crumple zone which lowers the maximum load(P_{max}) to P_1, the accordion buckling load. Recalculate your answer to (4) with this load. (5 pts)

(7) Determine the required section thickness as in (5) using the reduced moment from (6). (5 pts)

3. It is desired to avoid pitching upon impact. Let F_L be the average midrail force calculated in Problem 2. Assume that the upper rail force F_U is the only other force to balance the pitching of the vehicle (i.e., all other forces have a net zero moment about the CG) [25]



(1) Write the expression for the required upper rail crumpling force F_U as a function of the variables h, h_L and h_{UP}. (10 pts)

(2) For h = 500mm, h_L = 400mm, and h_{UP} = 900mm, what is the required average crush load for each upper rail F_U. (5 pts)

(3) What is the required upper rail square section size to meet (2) if the b/t ratio is 80 and σ_y = 207 N/mm^2? (10 pts)